

## CLAIMS

1. An optical element, comprising:  
a substrate in which grooves are formed;  
wherein the expression:  
5  $380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$   
is satisfied, where  $n$  is the refractive index of the substrate at a  
wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves; and  
wherein the grooves are formed in two steps of depth  $d$  and depth  
2d.  
10
2. An optical element, comprising:  
a substrate in which grooves are formed;  
wherein the expression:  
15  $380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$   
is satisfied, where  $n$  is a refractive index of the substrate at a  
wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves; and  
wherein the grooves are formed in four steps of depth  $d$ , depth  $2d$ ,  
depth  $3d$  and depth  $4d$ .
- 20 3. The optical head according to claim 2,  
wherein the depth of the grooves is lined up in the order: depth  
2d, depth 4d, depth  $d$ , depth  $3d$ , or in the order: depth  $3d$ , depth  $d$ , depth  
4d, depth 2d.
- 25 4. The optical element according to claim 1 or 2,  
wherein the grooves are formed in concentric ring-shapes.
5. The optical element according to claim 1 or 2,  
wherein the grooves are adjacent via a portion in which no  
30 grooves are formed, and the width of each step of the grooves is  
substantially the same as the width of the portion in which no grooves  
are formed.
- 35 6. An optical head, comprising:  
a first light source that emits light of a first wavelength that at  
least either records onto or reproduces information from a first  
information recording medium;

a second light source that emits light of a second wavelength that at least either records onto or reproduces information from a second information recording medium;

5 focusing means for focusing light that is emitted from the first light source and from the second light source;

an optical element that passes light of the first wavelength and diffracts light of the second wavelength; and

photodetecting means for detecting light of the first wavelength and light of the second wavelength;

10 wherein light of the first wavelength and light of the second wavelength pass through the optical element, after which they are focused by the focusing means and are irradiated onto the information recording media;

wherein the optical element is an optical element in which 15 grooves are formed in a substrate;

wherein the expression:

$$380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$$

is satisfied, where  $n$  is a refractive index of the substrate at a wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves;

20 wherein the grooves are formed in two steps of depth  $d$  and depth  $2d$ ; and

wherein the photodetecting means detects light that is at least either reflected or diffracted by the information recording media.

25 7. An optical head, comprising:

a first light source that emits light of a first wavelength, that at least either records onto or reproduces information from a first information recording medium;

30 a second light source that emits light of a second wavelength, that at least either records onto or reproduces information from a second information recording medium;

focusing means for focusing light that is emitted from the first light source and from the second light source;

35 an optical element that passes light of the first wavelength and diffracts light of the second wavelength; and

photodetecting means for detecting light of the first wavelength and light of the second wavelength;

- wherein light of the first wavelength and light of the second wavelength pass through the optical element, after which they are focused by the focusing means and are irradiated onto the information recording media;
- 5        wherein the optical element is an optical element in which grooves are formed in a substrate;
- wherein the expression:
- $380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$
- is satisfied, where  $n$  is a refractive index of the substrate at a
- 10       wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves;
- wherein the grooves are formed in four steps of depth  $d$ , depth  $2d$ , depth  $3d$  and depth  $4d$ ; and
- wherein the photodetecting means detects light that is at least either reflected or diffracted by the information recording media.
- 15
8.        The optical head according to claim 7,
- wherein the depth of the grooves is lined up in the order: depth  $2d$ , depth  $4d$ , depth  $d$ , depth  $3d$ , or in the order depth  $3d$ , depth  $d$ , depth  $4d$ , depth  $2d$ .
- 20
9.        The optical head according to claim 6 or 7,
- wherein the second wavelength is 1.5 to 1.8 times the length of the first wavelength.
- 25        10.       The optical head according to claim 6 or 7,
- wherein the grooves of the optical element are formed on a face that is close to the focusing means.
- 30        11.       The optical head according to claim 6 or 7,
- wherein for light of the second wavelength that is diffracted by the optical element, the light that diverges is stronger than the light that converges with respect to incident light.
- 35        12.       The optical head according to claim 6 or 7,
- wherein the optical element corrects the aberration to not more than  $70 \text{ m}\lambda$  when light of the second wavelength that is diffracted by the optical element is focused on an information surface of a second

information recording medium.

13. An optical head comprising:

5 a first light source that emits light of a first wavelength, that at least either records onto or reproduces information from a first information recording medium;

a second light source that emits light of a second wavelength, that at least either records onto or reproduces information from a second information recording medium;

10 a third light source that emits light of a third wavelength, that at least either records onto or reproduces information from a third information recording medium;

focusing means for focusing light that is emitted from the first light source, from the second light source and from the third light source;

15 a first optical element that passes light of the first wavelength and diffracts light of the second wavelength and light of the third wavelength; and

photodetecting means for detecting light of the first wavelength, light of the second wavelength and light of the third wavelength;

20 wherein light of the first wavelength, light of the second wavelength and light of the third wavelength pass through the optical element, after which they are focused by the focusing means and are irradiated onto the information recording media;

25 wherein the first optical element is an optical element in which grooves are formed in a substrate;

wherein the expression:

$$380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$$

is satisfied, where  $n$  is a refractive index of the substrate at a wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves;

30 wherein the grooves are formed in two steps of depth  $d$  and depth  $2d$ ; and

wherein the photodetecting means detects light that is at least either reflected or diffracted by the information recording media.

35 14. An optical head, comprising:

a first light source that emits light of a first wavelength, that at least either records onto or reproduces information from a first

information recording medium;

a second light source that emits light of a second wavelength, that at least either records onto or reproduces information from a second information recording medium;

5 a third light source that emits light of a third wavelength, that at least either records onto or reproduces information from a third information recording medium;

focusing means for focusing light that is emitted from the first light source, from the second light source and from the third light source;

10 a first optical element that passes light of the first wavelength and diffracts light of the second wavelength and the third wavelength; and

photodetecting means for detecting light of the first wavelength, light of the second wavelength and light of the third wavelength;

15 wherein light of the first wavelength, light of the second wavelength and light of the third wavelength pass through the optical element, after which they are focused by the focusing means and are irradiated onto the information recording media;

20 wherein the first optical element is an optical element in which grooves are formed in a substrate;

wherein the expression:

$$380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$$

is satisfied, where  $n$  is a refractive index of the substrate at a wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves;

25 wherein the grooves are formed in four steps of depth  $d$ , depth  $2d$ , depth  $3d$  and depth  $4d$ ; and

wherein the photodetecting means detects light that is at least either reflected or diffracted by the information recording media.

30 15. The optical head according to claim 14, wherein the depth of the grooves is lined up in the order: depth  $2d$ , depth  $4d$ , depth  $d$ , depth  $3d$ , or in the order depth  $3d$ , depth  $d$ , depth  $4d$ , depth  $2d$ .

35 16. The optical head according to claim 13 or 14, wherein the second wavelength is 1.5 to 1.8 times the length of the first wavelength; and

wherein the third wavelength is 1.8 to 2.2 times the length of the first wavelength.

17. The optical head according to claim 13 or 14,

5 wherein, when a first region is a substantially circle-shaped region in the central vicinity of the first optical element, a second region is a substantially ring-shaped region that surrounds the first region, and a third region is a region on the outside of the second region,

10 light of the first wavelength passes through the first, second and third region, light of the second wavelength passes through the first and second region, and light of the third wavelength passes through the first region.

18. The optical head according to claim 13 or 14,

15 wherein for light of the second wavelength and third wavelength that are diffracted by the first optical element, the light that diverges is stronger than the light that converges with respect to incident light.

19. The optical head according to claim 13 or 14, further comprising:

20 phase correcting means for correcting the aberration of light of the second wavelength that is diffracted by the first optical element to not more than  $70\text{ m}\lambda$  when light of the second wavelength is focused on the information surface of the second information recording medium, and  
for correcting the aberration of light of the third wavelength that  
25 is diffracted by the first optical element to not more than  $70\text{ m}\lambda$  when light of the third wavelength is focused on the information surface of the third information recording medium;

wherein the phase correcting means does not change the phase of light of the first wavelength; and

30 wherein the phase correcting means is provided in the light path between the light sources and the optical information recording medium.

20. The optical head according to claim 13 or 14, further comprising:

35 a second optical element that passes light of the first wavelength and light of the third wavelength, and diffracts light of the second wavelength;

wherein light of the first wavelength, light of the second

wavelength and light of the third wavelength pass through the two optical elements, after which they are focused by the focusing means, and irradiated onto the optical information recording medium.

- 5 21. The optical head according to claim 13 or 14, further comprising:  
a second optical element that passes light of the first wavelength and light of the third wavelength, and diffracts light of the second wavelength;

10 wherein light of the first wavelength, light of the second wavelength and light of the third wavelength pass through the two optical elements, after which they are focused by the focusing means, and irradiated onto the optical information recording medium;

wherein the second optical element is an optical element in which grooves are formed in a substrate;

15 wherein the expression:

$$760 \text{ nm} \leq (n - 1) \times d \leq 840 \text{ nm}$$

is satisfied, where  $n$  is a refractive index of the substrate at a wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves; and

20 wherein the grooves are formed in two steps of depth  $d$  and depth  $2d$ .

22. The optical head according to claim 13 or 14, further comprising:  
a second optical element that passes light of the first wavelength and light of the third wavelength, and diffracts light of the second wavelength;

25 wherein light of the first wavelength, light of the second wavelength and light of the third wavelength pass through the two optical elements, after which they are focused by the focusing means, and irradiated onto the optical information recording medium;

30 wherein the second optical element is an optical element in which grooves are formed in a substrate;

wherein the expression:

$$760 \text{ nm} \leq (n - 1) \times d \leq 840 \text{ nm}$$

35 is satisfied, where  $n$  is a refractive index of the substrate at a wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves; and

wherein the grooves are formed in three steps of depth  $d$ , depth  $2d$  and depth  $3d$ .

23. The optical head according to claim 13 or 14, further comprising:  
a second optical element that passes light of the first wavelength  
and light of the third wavelength, and diffracts light of the second  
5 wavelength;

wherein light of the first wavelength, light of the second  
wavelength and light of the third wavelength pass through the two  
optical elements, after which they are focused by the focusing means,  
and irradiated onto the optical information recording medium; and

10 wherein the first optical element and the second optical element  
are formed on a top and a rear of a single substrate.

24. The optical head according to claim 13 or 14, further comprising:  
a second optical element that passes light of the first wavelength  
15 and light of the third wavelength, and diffracts light of the second  
wavelength;

wherein light of the first wavelength, light of the second  
wavelength and light of the third wavelength pass through the two  
optical elements, after which they are focused by the focusing means,  
20 and irradiated onto the optical information recording medium; and

wherein the first optical element and the second optical element  
are formed on a top and a rear of a single substrate, and the face on  
which the second optical element is formed, of the two faces of the single  
substrate, is closer to the focusing means.

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25. The optical head according to claim 13 or 14, further comprising:  
a second optical element that passes light of the first wavelength  
and light of the third wavelength, and diffracts light of the second  
wavelength;

30 wherein light of the first wavelength, light of the second  
wavelength and light of the third wavelength pass through the two  
optical elements, after which they are focused by the focusing means,  
and irradiated onto the optical information recording medium; and

35 wherein the first and second optical elements correct the  
aberration of light of the second wavelength that is diffracted by the first  
and second optical elements to not more than  $70\text{ m}\lambda$  when that light is  
focused onto the information surface of the second information recording



medium; and

correct the aberration of light of the third wavelength that is diffracted by the first optical element to not more than  $70\text{ m}\lambda$  when that light is focused on the information surface of the third information recording medium.

26. The optical head according to claim 13 or 14,

wherein, when a distance between the surface of the first information recording medium on the focusing means side and the tip of the focusing means on the side of the first information recording medium is WD1 when light of the first wavelength is irradiated onto the first information recording medium, and

a distance between the surface of the second information recording medium on the focusing means side and the tip of the focusing means on the side of the second information recording medium is WD2 when light of the second wavelength is irradiated onto the second information recording medium, and

a distance between the surface of the third information recording medium on the focusing means side and the tip of the focusing means on the side of the third information recording medium is WD3 when light of the third wavelength is irradiated onto the third information recording medium,

a difference between the maximum value and the minimum value of WD1, WD2 and WD3 is smaller than the maximum value of the diameter of the focusing means.

27. The optical head according to claim 13 or 14,

wherein, when a distance between the surface of the first information recording medium on the focusing means side and the tip of the focusing means on the side of the first information recording medium is WD1 when light of the first wavelength is irradiated onto the first information recording medium, and

a distance between the surface of the second information recording medium on the focusing means side and the tip of the focusing means on the side of the second information recording medium is WD2 when light of the second wavelength is irradiated onto the second information recording medium, and

a distance between the surface of the third information recording medium on the focusing means side and the tip of the focusing means on the side of the third information recording medium is WD3 when light of the third wavelength is irradiated onto the third information recording medium,

WD1, WD2 and WD3 are substantially equivalent.

28. The optical head according to claim 6, 7, 13 or 14, further comprising:

10 a converter for converting a plurality of signals, which are received in parallel and are output from the photodetecting means into a serial signal.

29. The optical head according to claim 6, 7, 13 or 14, further comprising:

15 a converter for converting a plurality of signals, which are received in parallel and are output from the photodetecting means, into a serial signal;

wherein the serial signal is an electrical signal.

20 30. The optical head according to claim 6, 7, 13 or 14, further comprising:

a first converter for converting a plurality of signals, which are output from the photodetecting means and received in parallel, into a serial signal; and

25 a second converter for receiving the electric signal that is output from the first converter and for converting the electric signal into an optical signal.

30 31. An optical information recording and reproduction apparatus, comprising:

an optical head that includes;

a first light source that emits light of a first wavelength, that at least either records onto or reproduces information from a first information recording medium;

35 a second light source that emits light of a second wavelength, that at least either records onto or reproduces information from a second

information recording medium;

focusing means for focusing light that is emitted from the first light source and from the second light source;

an optical element that passes light of the first wavelength and  
5 diffracts light of the second wavelength; and

photodetecting means for detecting light of the first wavelength and light of the second wavelength,

further comprising:

moving means for moving the information recording medium and  
10 the optical head relative to each other;

wherein light of the first wavelength and light of the second wavelength pass through the optical element, after which they are focused by the focusing means and are irradiated onto the information recording media;

15 wherein the optical element is an optical element in which grooves are formed in a substrate;

wherein the expression:

$$380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$$

is satisfied, where  $n$  is a refractive index of the substrate at a  
20 wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves;

wherein the grooves are formed in two steps of depth  $d$  and depth  $2d$ ; and

wherein the photodetecting means detects light that is at least either reflected or diffracted by the information recording media.

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32. An optical information recording and reproduction apparatus, comprising:

an optical head that includes;

a first light source that emits light of a first wavelength, that at  
30 least either records onto or reproduces information from a first information recording medium;

a second light source that emits light of a second wavelength, that at least either records onto or reproduces information from a second information recording medium;

35 focusing means for focusing light that is emitted from the first light source and from the second light source;

an optical element that passes light of the first wavelength and

diffraction of light of the second wavelength; and

photodetecting means for detecting light of the first wavelength and light of the second wavelength,

further comprising:

5 moving means for moving the information recording medium and the optical head relative to each other;

wherein light of the first wavelength and light of the second wavelength pass through the optical element, after which they are focused by the focusing means and are irradiated onto the information recording media;

wherein the optical element is an optical element in which grooves are formed in a substrate;

wherein the expression:

$$380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$$

15 is satisfied, where  $n$  is a refractive index of the substrate at a wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves;

wherein the grooves are formed in four steps of depth  $d$ , depth  $2d$ , depth  $3d$  and depth  $4d$ ; and

wherein the photodetecting means detects light that is at least either reflected or diffracted by the information recording media.

33. The optical information recording and reproduction apparatus according to claim 32,

wherein the grooves are lined up in the order: depth  $2d$ , depth  $4d$ , depth  $d$ , depth  $3d$ , or in the order depth  $3d$ , depth  $d$ , depth  $4d$ , depth  $2d$ .

34. An optical information recording and reproduction apparatus, comprising:

an optical head that includes;

30 a first light source that emits light of a first wavelength, that at least either records onto or reproduces information from a first information recording medium;

a second light source that emits light of a second wavelength, that at least either records onto or reproduces information from a second information recording medium;

35 a third light source that emits light of a third wavelength, that at least either records onto or reproduces information from a third

information recording medium;

focusing means for focusing light that is emitted from the first light source, from the second light source and from the third light source;

5 a first optical element that passes light of the first wavelength and diffracts light of the second wavelength and light of the third wavelength; and

photodetecting means for detecting light of the first wavelength, light of the second wavelength and light of the third wavelength;

further comprising:

10 moving means for moving the information recording medium and the optical head relative to each other;

wherein light of the first wavelength, light of the second wavelength and light of the third wavelength pass through the optical element, after which they are focused by the focusing means and are  
15 irradiated onto the information recording media;

wherein the first optical element is an optical element in which grooves are formed in a substrate;

wherein the expression:

$$380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$$

20 is satisfied, where  $n$  is a refractive index of the substrate at a wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves;

wherein the grooves are formed in two steps of depth  $d$  and depth  $2d$ ; and

25 wherein the photodetecting means detects light that is at least either reflected or diffracted by the information recording media.

35. An optical information recording and reproduction apparatus, comprising:

an optical head that includes;

30 a first light source that emits light of a first wavelength, that at least either records onto or reproduces information from a first information recording medium;

a second light source that emits light of a second wavelength, that at least either records onto or reproduces information from a second  
35 information recording medium;

a third light source that emits light of a third wavelength, that at least either records onto or reproduces information from a third

information recording medium;

focusing means for focusing light that is emitted from the first light source, from the second light source and from the third light source;

5 a first optical element that passes light of the first wavelength and diffracts light of the second wavelength and light of the third wavelength; and

photodetecting means for detecting light of the first wavelength, light of the second wavelength and light of the third wavelength;

further comprising:

10 moving means for moving the information recording medium and the optical head relative to each other;

wherein light of the first wavelength, light of the second wavelength and light of the third wavelength pass through the optical element, after which they are focused by the focusing means and are  
15 irradiated onto the information recording media;

wherein the first optical element is an optical element in which grooves are formed in a substrate;

wherein the expression:

$$380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$$

20 is satisfied, where  $n$  is a refractive index of the substrate at a wavelength of 400 nm, and  $d$  (nm) is a depth per step of the grooves;

wherein the grooves are formed in four steps of depth  $d$ , depth  $2d$ , depth  $3d$  and depth  $4d$ ; and

25 wherein the photodetecting means detects light that is at least either reflected or diffracted by the information recording media.

36. The optical information recording and reproduction apparatus according to claim 34 and 35, further comprising:

30 a second optical element that passes light of the first wavelength and light of the third wavelength, and diffracts light of the second wavelength;

wherein light of the first wavelength, light of the second wavelength and light of the third wavelength pass through the two optical elements, after which they are focused by the focusing means,  
35 and irradiated onto the optical information recording medium.

37. An optical element, comprising:

a substrate, in which steps are formed protruding from a flat surface thereof;

wherein the expression:

$$760 \text{ nm} \leq (n - 1) \times d \leq 840 \text{ nm}$$

5 is satisfied when a refractive index of the substrate at a wavelength of 400 nm is  $n$ , and a height (nm) of one step is  $d$ ; and

wherein the height of the steps is an integer multiple of  $d$ .

38. The optical element according to claim 37,  
10 wherein the steps are formed in concentric ring-shapes.

39. An optical head, comprising:  
a first light source that emits light of a first wavelength that is in  
a range of 380 nm to 420 nm and that at least either records onto or  
15 reproduces information from a first information recording medium;

a second light source that emits light of a second wavelength,  
that at least either records onto or reproduces information from a second  
information recording medium;

20 an optical element that passes light of the first wavelength, and  
converts the phase of light of the second wavelength;

focusing means for focusing light of the first wavelength and light  
of the second wavelength onto the information recording medium;

detecting means for detecting light of the first wavelength and  
light of the second wavelength;

25 wherein the optical element is an optical element comprising a  
substrate, in which steps are formed protruding from a flat surface  
thereof; and

wherein the expression:

$$760 \text{ nm} \leq (n - 1) \times d \leq 840 \text{ nm}$$

30 is satisfied when a refractive index of the substrate at a wavelength of 400 nm is  $n$ , and a height (nm) of one step is  $d$ .

40. An optical head, comprising:  
a first light source that emits light of a first wavelength that is in  
35 a range of 380 nm to 420 nm and that at least either records onto or  
reproduces information from a first information recording medium;

a second light source that emits light of a second wavelength,

that at least either records onto or reproduces information from a second information recording medium;

an optical element that passes light of the first wavelength, and converts the phase of light of the second wavelength;

5 focusing means for focusing light of the first wavelength and light of the second wavelength onto the information recording medium; and

detecting means for detecting light of the first wavelength and light of the second wavelength;

wherein the position of the second light source is set closer to the  
10 focusing means than a position at which the aberration at the information recording surface of the second information recording medium, when the optical element is not present, is at a minimum;

wherein the optical element is an optical element comprising a substrate, in which steps are formed protruding from a flat surface  
15 thereof; and

wherein the expression:

$$380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$$

is satisfied when a refractive index of the substrate at a wavelength of 400 nm is n, and a height (nm) of one step is d.

20

41. An optical head, comprising:

a first light source that emits light of a first wavelength that is in a range of 380 nm to 420 nm and that at least either records onto or reproduces information from a first information recording medium;

25 a second light source that emits light of a second wavelength, that at least either records onto or reproduces information from a second information recording medium;

an optical element that passes light of the first wavelength, and converts the phase of light of the second wavelength;

30 focusing means for focusing light of the first wavelength and light of the second wavelength onto the information recording medium; and

detecting means for detecting light of the first wavelength and light of the second wavelength;

wherein the position of the second light source is set further from  
35 the focusing means than a position that is substantially midway between the position of that light source at which the aberration at the information recording surface of the second information recording



medium when the optical element is not present is at a minimum, and the position of that light source at which light of the second wavelength that is incident on the focusing means is collimated light;

5 wherein the optical element is an optical element comprising a substrate, in which steps are formed protruding from a flat surface thereof; and

wherein the expression:

$$380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$$

10 is satisfied when a refractive index of the substrate at a wavelength of 400 nm is n, and a height (nm) of one step is d.

42. The optical head according to claim 39, 40 or 41, further comprising:

15 tilting means for tilting the focusing means.

43. An optical head comprising:

a first light source that emits light of a first wavelength that is in a range of 380 nm to 420 nm and that at least either records onto or reproduces information from a first information recording medium;

20 a second light source that emits light of a second wavelength, that at least either records onto or reproduces information from a second information recording medium;

an optical element that passes light of the first wavelength, and converts the phase of light of the second wavelength;

25 focusing means for focusing light of the first wavelength and light of the second wavelength onto the information recording medium; and

detecting means for detecting light of the first wavelength and light of the second wavelength;

30 wherein light of the second wavelength that is incident on the focusing means is collimated light;

wherein the optical element is an optical element comprising a substrate, in which steps are formed protruding from a flat surface thereof; and

wherein the expression:

35 
$$380 \text{ nm} \leq (n - 1) \times d \leq 420 \text{ nm}$$

is satisfied when a refractive index of the substrate at a wavelength of 400 nm is n, and a height (nm) of one step is d.

44. The optical head according to claim 39, 40, 41 or 43,  
 wherein the optical element corrects the aberration to not more  
 than 70 mλ when light of the second wavelength is focused on the  
 5 information recording surface of the second information recording media.
45. An optical head, comprising:  
 a first light source that emits light of a first wavelength that is in  
 a range of 380 nm to 420 nm and that at least either records onto or  
 10 reproduces information from a first information recording medium;  
 a second light source that emits light of a second wavelength,  
 that at least either records onto or reproduces information from a second  
 information recording medium;  
 a third light source that emits light of a third wavelength, that at  
 15 least either records onto or reproduces information from a third  
 information recording medium;  
 an optical element that passes light of the first wavelength and  
 light of the third wavelength, and converts the phase of light of the  
 second wavelength;  
 20 focusing means for focusing light of the first wavelength, light of  
 the second wavelength and light of the third wavelength onto the  
 information recording medium; and  
 detecting means for detecting light of the first wavelength, light  
 of the second wavelength and light of the third wavelength;  
 25 wherein the optical element is an optical element comprising a  
 substrate, in which steps are formed protruding from a flat surface  
 thereof; and  
 wherein the expressions:  

$$760 \text{ nm} \leq (n_1 - 1) \times d \leq 840 \text{ nm}$$
  
 30 and  

$$-10 \text{ nm} < \lambda_1 / (n_1 - 1) - \lambda_3 / (n_3 - 1) / 2 < 10 \text{ nm}.$$
  
 are satisfied when a refractive index of the optical element at the  
 wavelength of 400nm is n, the third wavelength is λ<sub>3</sub> (nm), a refractive  
 index of the optical element at the wavelength λ<sub>3</sub> is n<sub>3</sub>, and a height  
 35 (nm) of one step is d.
46. An optical head, comprising:

a first light source that emits light of a first wavelength that is in a range of 380 nm to 420 nm and that at least either records onto or reproduces information from a first information recording medium;

5 a second light source that emits light of a second wavelength, that at least either records onto or reproduces information from a second information recording medium;

a third light source that emits light of a third wavelength, that at least either records onto or reproduces information from a third information recording medium;

10 an optical element that passes light of the first wavelength and light of the third wavelength, and changes the phase of light of the second wavelength;

a liquid crystal element that passes light of the first wavelength and light of the second wavelength, and diffracts light of the third wavelength;

15 focusing means for focusing light of the first wavelength, light of the second wavelength and light of the third wavelength onto the information recording medium; and

20 detecting means for detecting light of the first wavelength, light of the second wavelength and light of the third wavelength;

wherein the optical element is an optical element comprising a substrate, in which steps are formed protruding from a flat surface thereof;

wherein the expression:

25  $700 \text{ nm} \leq (n - 1) \times d \leq 840 \text{ nm}$

is satisfied when a refractive index of the substrate at a wavelength of 400 nm is n, and a height (nm) of one step is d; and

wherein the liquid crystal element comprises:

a substrate that has a relief-shaped hologram pattern;

30 a first transparent electrode, which is formed on the relief-shaped hologram pattern; and

a second transparent electrode that is arranged opposite the first transparent electrode to sandwich the liquid crystal;

35 wherein the liquid crystal element passes light of the first wavelength and light of the second wavelength, and diffracts light of the third wavelength by controlling a voltage that is applied to the first transparent electrode and the second transparent electrode.

47. An optical information recording and reproduction apparatus,  
comprising:  
an optical head according to claim 39, 40, 41, 43, 45 or 46; and  
5 moving means for moving the information recording media and  
the optical head relative to each other.
48. A computer, comprising:  
an optical information recording and reproduction apparatus that  
10 includes an optical head according to claim 6, 7, 13, 14, 39, 40, 41, 43, 45  
or 46,  
as an external storage device.
49. An image recording device, comprising:  
15 an optical information recording and reproduction apparatus that  
includes an optical head according to claim 6, 7, 13, 14, 39, 40, 41, 43, 45  
or 46;  
which can at least record images from among recording images  
onto and reproducing images from an information recording medium.  
20
50. An image reproduction device, comprising:  
an optical information recording and reproduction apparatus that  
includes an optical head according to claim 6, 7, 13, 14, 39, 40, 41, 43, 45  
or 46;  
25 wherein it specializes in reproducing images from an information  
recording medium.
51. A server, comprising:  
an optical information recording and reproduction apparatus that  
30 includes an optical head according to claim 6, 7, 13, 14, 39, 40, 41, 43, 45  
or 46, as an external storage device.
52. A car navigation system, comprising:  
an optical information recording and reproduction apparatus that  
35 includes an optical head according to claim 6, 7, 13, 14, 39, 40, 41, 43, 45  
or 46, as an external storage device.